

Work Order ID 52126

September 16, 2009 2:26:41 PM

Page 1

Item ID: D2917-1

Accept

Revision ID: B

Item Name: Saddle LH

Setup Start

Stop

Start Date: 09/30/2009 Start Qty: 10.00

Required Date: 10/05/2009 Req'd Qty: 10.00

Cust Item ID:

Customer:

Reference:

Approvals:

Process Plan: cmf

Date: 09-09-16 Tooling:

Date:

QC:

Date:

SPC (Y/N):

Date:

Run Start

Stop

Sequence ID/
Work Center ID

Operation
Description

Set Up/
Run Hours

Draw
Number

Draw
Rev.

Plan
Code

Accept
Qty

Reject
Qty

Reject
Number

Insp.
Stamp

Draw Nbr

Revision Nbr

D2917

Rev B

100

0.00



HAAS CNC VERTICAL MACHINING #1

HAAS I

Memo

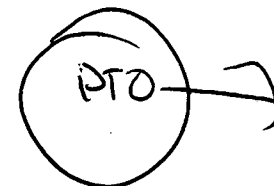
0.00

HAAS CNC vertical machine #1

Program batch number Machine Step No 1 as per Folio FA436 and visually inspect as per Dwg D2917 & attached Dimension Sheet Machine Step No 2 as per Folio FA436 and visually inspect as per Dwg D2917 & attached Dimension Sheet Machine Step No 3 as per Folio

SP 09/09/29

10



110

0.00



CONVENTIONAL MILLING MACHINE

Mill Conv

Memo

0.00

Conventional Milling Machine

Machine Keyway and inspect per Dwg D2917 & attached dimension sheet

SP 09/09/29

10

120

0.00



QC2- Inspect parts off machine FAI/FAIB

QC

Memo

0.00

Quality Control

SP 09/09/29

10

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: D2917-1 PAR #: _____ Fault Category: Prod. Machined Parts NCR: Yes No DQA: _____ Date: 05-10-05
 Resolution: Accepted Disposition: USE AS IS. QA: N/C Closed: _____ Date: 05-10-05

NCR: <u>52126</u>		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			
<u>09/09/29</u>	<u>100</u>	<u>One saddle is affected by a chamfer too big on the flange. chamfer .0.100"±.010 is .170".</u>	<u>CP</u> <u>09.09.29</u> <u>OS/042</u>	<u>PART ACCEPTABLE</u>	<u>SP</u> <u>09/09/29</u>	<u>DIP</u> <u>09/09/30</u>	<u>CP</u> <u>09.09.29</u> <u>7"</u> <u>OS/042</u>	<u>S</u> <u>09/10/04</u>
		<u>R.C. Fix Follow</u> <u>NEW INSERT TOOL</u> <u>(NOT THE SAME GEOMETRY)</u>	<u>[Signature]</u> <u>OS/042</u>	<u>update folio.</u>	<u>[Signature]</u>	<u>DIP</u> <u>09/09/30</u>	<u>[Signature]</u> <u>OS/042</u>	<u>[Signature]</u> <u>09/10/04</u>
<u>09/10/01</u>	<u>100</u>	<u>SADDLE-TO-CRUSTUBE WALL THICKNESS IS 0.170" IN SOME AREAS</u>	<u>CP</u> <u>09.10.01</u> <u>pc</u> <u>OS/042</u>	<u>PARTS ACCEPTABLE</u> <u>PER ATTACHED SR.</u>	<u>AMR</u> <u>09/10/01</u>	<u>S</u> <u>09/10/01</u>	<u>CP</u> <u>09.10.01</u> <u>pc</u> <u>OS/042</u>	<u>S</u> <u>09/10/01</u>

NOTE: Date & initial all entries

Work Order ID 52126

September 16, 2009 2:26:41 PM

Page 2

Item ID: D2917-1

Accept

Revision ID: B

Item Name: Saddle LH

Setup Start

Stop

Start Date: 09/30/2009 Start Qty: 10.00

Required Date: 10/05/2009 Req'd Qty: 10.00

Cust Item ID:

Customer:

Reference:

Approvals:

Process Plan:

Date:

Tooling:

Date:

Run Start

Stop

QC:

Date:

SPC (Y/N):

Date:

Sequence ID/
Work Center ID

Operation
Description

Set Up/
Run Hours

Draw
Number

Draw
Rev.

Plan
Code

Accept
Qty

Reject
Qty

Reject
Number

Insp.
Stamp

130

QC8- Inspect parts - second check

0.00



QC

Memo

0.00

DI 09/30

10

Quality Control

140

Chemical Conversion Coat per QSI005 4.1

0.00



HandFinish

Memo

0.00

0000-01

10

Hand Finishing

150

White Gloss(Ref:4.3.5.1) per QSI005 4.3-Alum

0.00



Powdercoat

Memo

0.00

7 11/09/10/01

X10

10

Powder Coating

START TIME: 1:00 PM FINISH TIME: 1:30 PM OVEN TEMPERATURE: 320°F

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

Work Order ID 52126

September 16, 2009 2:26:41 PM



Page 3

Item ID: D2917-1

Accept



Setup Start



Revision ID: B

Stop



Item Name: Saddle LH

Start Date: 09/30/2009 Start Qty: 10.00



Cust Item ID:

Required Date: 10/05/2009 Req'd Qty: 10.00



Customer:

Reference:

Run Start



Approvals: Process Plan: _____ Date: _____ Tooling: _____ Date: _____

Stop



QC: _____ Date: _____ SPC (Y/N): _____ Date: _____

Sequence ID/ Work Center ID	Operation Description	Set Up/ Run Hours	Draw Number	Draw Rev.	Plan Code	Accept Qty	Reject Qty	Reject Number	Insp. Stamp
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160

QC3- Inspect Part Finish

0.00



QC

Memo

0.00

Quality Control

Q.M. 09-10-01 (10)

170

Identify as per dwg & Stock Location: _____

0.00



Packaging

Memo

0.00

Packaging

9/10/5 (10) SF

180

QC21- Final Inspection - Work Order Release

0.00



QC

Memo

0.00

Quality Control

09/10/05 (10) SF
M 09-10-5

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

Picklist Print

September 16, 2009 2:26:41 PM

Page 1

Work Order ID: 52126

Parent Item: D2917-1RevB

Parent Item Name: Saddle LH

Comments:

Start Date: 09/30/2009

Required Date: 10/05/2009

Start Qty: 10.00

Required Qty: 10.00

Component Item ID/ Item Name	Replacement Item ID	Mfg/ Purch	Bin Item	Primary Location	Last Location	Route Seq ID	Unit of Measure	Qty on Hand	Remaining Qty To Pick	Qty Issued	Date Issued	Status
D6102-010RevD		Manufactured	No			100	Each	6.0000	10.0000			



Saddle Billet



88 09/29/29

Warehouse

Loc Qty

Loc Code

Location

Main Warehouse

MAT

6

51423

6

52067

,

10

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

DART AEROSPACE LTD		Work Order: 52126
Description: Saddle LH		Part Number: D2917-1
Inspection Dwg: D2917 Rev. A1		Page 1 of 1

Inspect dimensions highlighted on inspection sheet drawing D2917 Rev. A1 and record below:

Dim	Min	Max	Go/No Go Gauge	Recorded Actual Dimensions				By	Date
				1	2	3	4		
A	0.175	0.205		.196	.195	.195	.195		
B	0.090	0.110		.170	.100	.100	.100		
C	0.250	0.270		.263	.265	.265	.265		
D	1.599	1.619		1.618	1.612	1.612	1.612		
E	0.180	0.220		.180	.180	.180	.185		
F	0.277	0.297		.292	.292	.293	.290		
G	1.385	1.400		1.392	1.392	1.392	1.390		
H	3.170	3.230		3.207	3.207	3.207	3.207		
I	0.175	0.217		.176	.186	.185	.185		
J	0.470	0.530		.500	.500	.500	.500		
K	1.498	1.508		1.501	1.500	1.500	1.500		
L	4.436	4.446		4.440	4.440	4.440	4.440		
M	0.257	0.262	DT8683	.253	.258	.258	.258		
N	1.225	1.235		1.229	1.229	1.229	1.230		
O	1.103	1.113		1.108	1.108	1.108	1.108		
P	0.470	0.530		.500	.500	.500	.500		
Q	0.438	0.443	DT8682	.440	.440	.440	.440		
R	0.490	0.510		.502	.502	.504	.504		
S	1.745	1.755		1.752	1.750	1.750	1.750		
T	7.990	8.010		8.000	8.000	8.000	8.000		
U	3.495	3.505		3.500	3.500	3.500	3.500		
V	0.175	0.205		.190	.200	.196	.196		
W	1.990	2.010		2.008	2.008	2.008	2.000		
X	0.760	0.765		.760	.761	.761	.761		
Y	0.307	0.312		.310	.311	.311	.310		
Z	0.615	0.635		.628	.631	.630	.630		
AA	0.177	0.197		.180	.190	.190	.190		
AB									
AC									
AD									
AE									
AF									
AG									
AH									
Accept/Reject									

Measured by: <i>SL</i>
Date: 02/09/29

Audited by: <i>DTA</i>
Date: 02/09/30

Rev	Date	Change	Revised by	Approved
A	04.08.12	New Issue	KJ/JLM	
B	04.09.20	Added DT8683 & DT8682	KJ/JLM <i>JA</i>	<i>JA</i>

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

DART AEROSPACE LTD		Work Order: 52126
Description: Saddle LH		Part Number: D2917-1
Inspection Dwg: D2917 Rev. A1		Page 1 of 1

Inspect dimensions highlighted on inspection sheet drawing D2917 Rev. A1 and record below:

				Recorded Actual Dimensions					
Dim	Min	Max	Go/No Go Gauge	57	62	72	84	By	Date
A	0.175	0.205		.195	.195	.195	.195		
B	0.090	0.110		.100	.100	.100	.100		
C	0.250	0.270		.265	.265	.265	.265		
D	1.599	1.619		1.615	1.615	1.615	1.615		
E	0.180	0.220		.195	.195	.195	.195		
F	0.277	0.297		.290	.290	.290	.290		
G	1.385	1.400		1.390	1.392	1.392	1.390		
H	3.170	3.230		3.200	3.200	3.200	3.200		
I	0.175	0.217		.195	.190	.178	.180		
J	0.470	0.530		.500	.500	.500	.500		
K	1.498	1.508		1.503	1.503	1.503	1.503		
L	4.436	4.446		4.440	4.440	4.440	4.440		
M	0.257	0.262	DT8683	.253	.253	.253	.253		
N	1.225	1.235		1.230	1.230	1.230	1.230		
O	1.103	1.113		1.108	1.108	1.108	1.108		
P	0.470	0.530		.500	.500	.500	.500		
Q	0.438	0.443	DT8682	.440	.440	.440	.440		
R	0.490	0.510		.504	.504	.504	.504		
S	1.745	1.755		1.750	1.750	1.750	1.750		
T	7.990	8.010		8.000	8.000	8.000	8.000		
U	3.495	3.505		3.500	3.500	3.500	3.500		
V	0.175	0.205		.185	.190	.190	.190		
W	1.990	2.010		2.000	2.000	2.000	2.000		
X	0.760	0.765		.760	.760	.760	.760		
Y	0.307	0.312		.310	.310	.310	.310		
Z	0.615	0.635		.628	.628	.628	.628		
AA	0.177	0.197		.186	.186	.186	.186		
AB									
AC									
AD									
AE									
AF									
AG									
AH									
Accept/Reject									

Measured by: <i>ST</i>
Date: 09/09/29

Audited by: <i>DT</i>
Date: 09/09/30

Rev	Date	Change	Revised by	Approved
A	04.08.12	New Issue	KJ/JLM	
B	04.09.20	Added DT8683 & DT8682	KJ/JLM	

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

DART AEROSPACE LTD	Work Order:	52126
Description: Saddle LH	Part Number:	D2917-1
Inspection Dwg: D2917 Rev. A1		Page 1 of 1

Inspect dimensions highlighted on inspection sheet drawing D2917 Rev. A1 and record below:

				Recorded Actual Dimensions					
Dim	Min	Max	Go/No Go Gauge	1	2	3	4	By	Date
A	0.175	0.205		.190	.190				
B	0.090	0.110		.100	.100				
C	0.250	0.270		.265	.265				
D	1.599	1.619		1.45	1.615				
E	0.180	0.220		.195	.195				
F	0.277	0.297		.290	.290				
G	1.385	1.400		1.390	1.392				
H	3.170	3.230		3.200	3.200				
I	0.175	0.217		.190	.190				
J	0.470	0.530		.500	.500				
K	1.498	1.508		1.503	1.503				
L	4.436	4.446		4.440	4.440				
M	0.257	0.262	DT8683	.253	.253				
N	1.225	1.235		1.230	1.230				
O	1.103	1.113		1.108	1.108				
P	0.470	0.530		.500	.500				
Q	0.438	0.443	DT8682	.440	.440				
R	0.490	0.510		.504	.500				
S	1.745	1.755		1.750	1.750				
T	7.990	8.010		8.000	8.000				
U	3.495	3.505		3.500	3.500				
V	0.175	0.205		.185	.185				
W	1.990	2.010		2.003	2.000				
X	0.760	0.765		.760	.760				
Y	0.307	0.312		.310	.310				
Z	0.615	0.635		.628	.628				
AA	0.177	0.197		.186	.186				
AB									
AC									
AD									
AE									
AF									
AG									
AH									
Accept/Reject									

Measured by:	<i>[Signature]</i>
Date:	07/09/30

Audited by:	<i>[Signature]</i>
Date:	09/09/30

Rev	Date	Change	Revised by	Approved
A	04.08.12	New Issue	KJ/JLM	
B	04.09.20	Added DT8683 & DT8682	KJ/JLM <i>[Signature]</i>	<i>[Signature]</i>

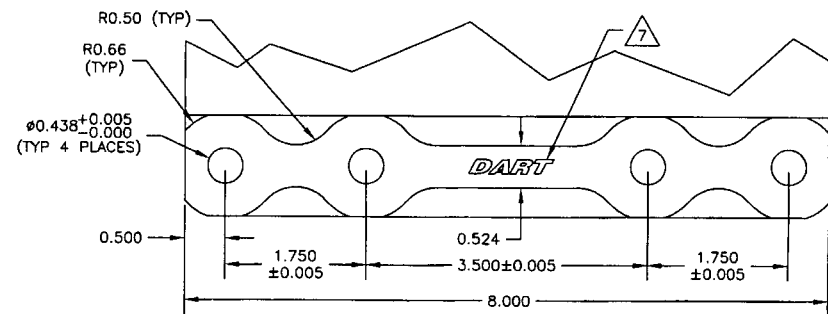
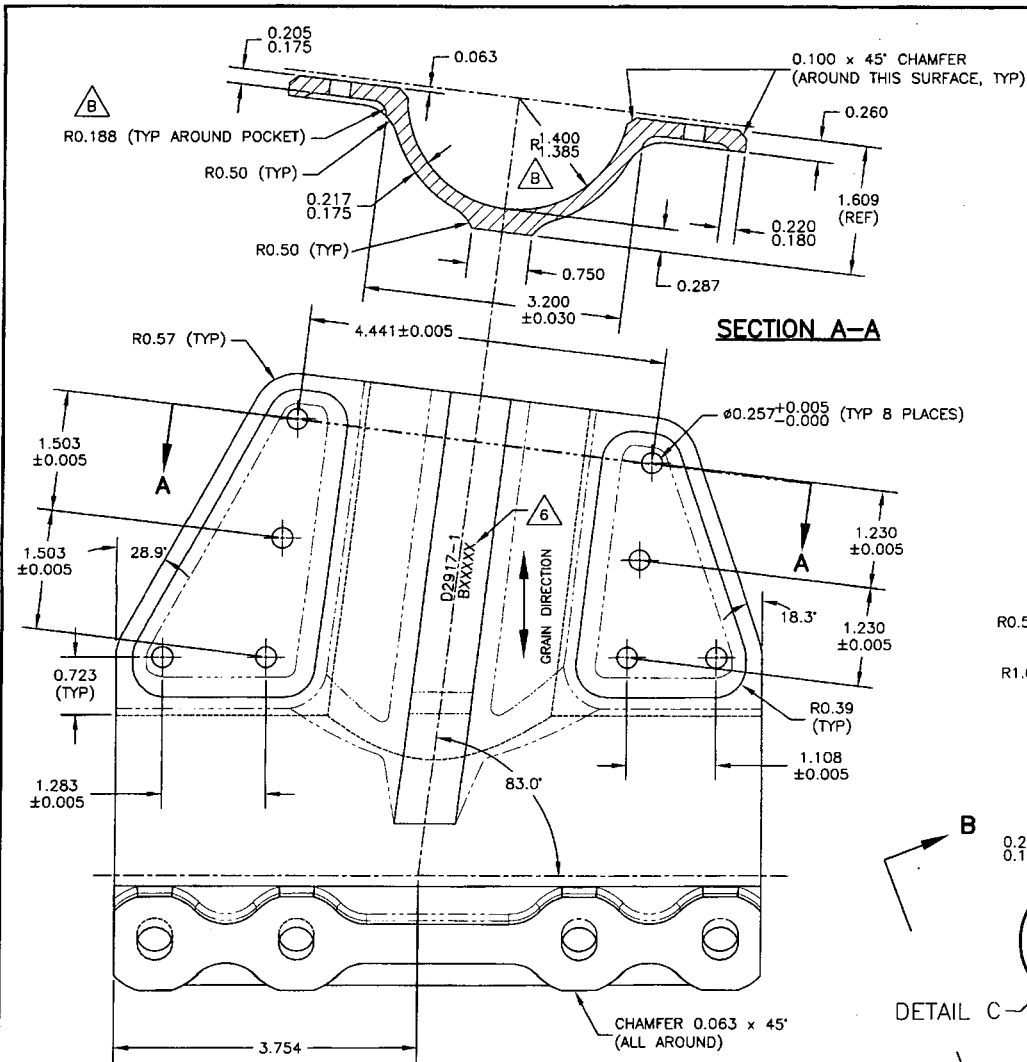
W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

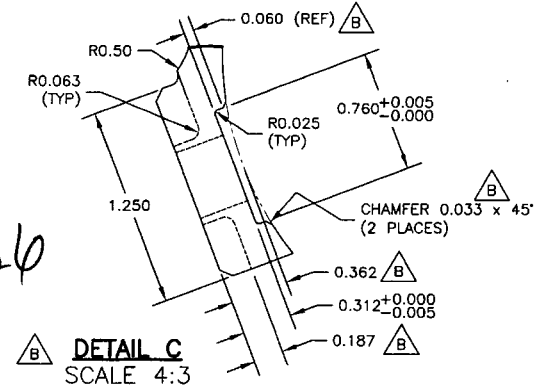
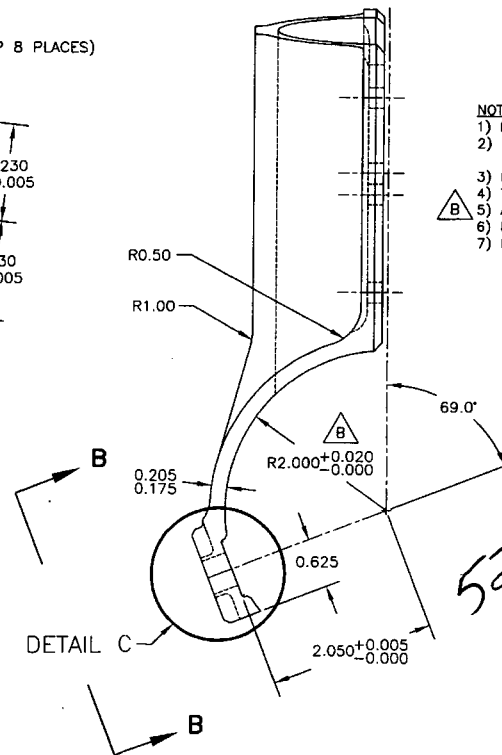
NOTE: Date & initial all entries



VIEW B-B

D2917-1 LH SADDLE (SHOWN)
D2917-2 RH SADDLE (OPPOSITE)

- NOTES:
- 1) MATERIAL: ALUMINUM 6061-T6/T651 PER QQ-A-250/11
 - 2) FINISH: CHEMICAL CONVERSION COAT PER DART QSI 005 4.1
POWDER COAT GLOSS WHITE (REF 4.3.5.1) PER DART QSI 005 4.3
 - 3) BREAK ALL SHARP EDGES 0.010 TO 0.020
 - 4) TOLERANCES ARE PER DART QSI 018 UNLESS OTHERWISE NOTED.
 - 5) ALL DIMENSIONS ARE IN INCHES
 - 6) ENGRAVE PART AND BATCH NUMBER IN THIS AREA TO MAX DEPTH OF 0.010
 - 7) ENGRAVE DART LOGO TO MAX DEPTH OF 0.015 WITH MIN RAD 0.125



RELEASED

C7.07.31

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 AND IS SUPPLIED ON THE EXPRESS CONDITION
 THAT IT IS NOT TO BE USED FOR ANY PURPOSE
 OR COPIED OR COMMUNICATED TO ANY OTHER
 PERSON WITHOUT WRITTEN PERMISSION FROM
 DART AEROSPACE LTD.

B	07.06.26	ADD 0.362, 0.187, 0.060, CHAMFER; ADD DETAIL C; R0.188 WAS R0.30; ADD TOL TO R2.000; ADD NOTES
A	04.05.31	NEW ISSUE
DESIGN	9P	DRAWN BY CB
CHECKED	PH	APPROVED
DATE	07.06.26	TITLE SADDLE
		DART AEROSPACE LTD. MARKHAM, ONTARIO, CANADA
		DRAWING NO. D2917
		REV. B
		SHEET 1 OF 1
		SCALE 2:3

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

5.0 Saddle Geometry

5.1 General Information

ctubefwd := 1.388 · in
ctubeaft := 1.50 · in

Fwd crosstube bore radius (see dwg D2917/D2918)
Aft crosstube bore radius (see dwg D2919/D2920)

5.2 Bell Saddles

The forward and aft Bell saddles are one-piece aluminum forgings, part numbers 209-052-204-3 (fwd saddle) and 209-052-204-1 (aft saddle). Figure 3 in Reference 1 at the end of this report shows the Bell saddle geometry.

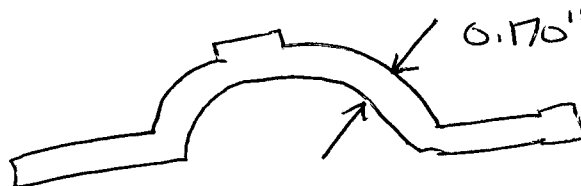
n4 := 6	Number of MS27039-4-13 screws in bearing & shear
d4 := 0.250 · in	Diameter of MS27039-4-13 screws
n5 := 8	Number of MS27039-5-14 screws in bearing & shear
d5 := 0.312 · in	Diameter of MS27039-5-14 screws
tmatf := 0.125 · in	Fwd Bell forged saddle material thickness (minimum)
tmata := 0.155 · in	Aft Bell forged saddle material thickness (minimum)
ncb := 12	Number of crosstube rivet bearing & shear areas
dcb := 0.313 · in	Hole size for crosstube rivets
Lb := 8.00 · in	Length of Bell saddles
e := 0.5 · in	Edge distance for MS27039 screws
e4 := e - d4	Tearout distance for MS27039-4-13 screws
e5 := e - d5	Tearout distance for MS27039-5-14 screws
e4 = 0.25 · in	
e5 = 0.19 · in	

5.3 Dart Saddles

The geometry of a typical Dart saddle is illustrated in Figure 2 of Reference 1 at the end of this report. These dimensions have been taken from dwgs D2917-D2918, which are the replacement parts for 209-052-204-3, and dwgs D2918-D2919, which are the replacement parts for 209-052-204-1.

nt := 8	Number of skidtube bolt shear areas
tw := 0.750 · in	Rib width
tover := 0.245 · in	Overhang thickness
wf := 0.750 · in	Skidtube flange width
Df := 0.438 · in	Diameter of saddle flange bolt holes
$ef := \frac{wf - Df}{2} + tover$	Flange edge distance
ef = 0.4 · in	
g := .125 · in	Gap between inboard-outboard saddles
dcd := 0.313 · in	Hole size for crosstube bolts (see dwg D2917-D2920)
ncd := 4	Number of crosstube bolt shear areas
txf := 0.265 · in	Fwd min. material thickness near saddle xtube bolt holes
txa := 0.315 · in	Aft min. material thickness near saddle xtube bolt holes
Ld := 8 · in	Length of Dart saddles
tg := 0.313 · in	Thickness of saddle groove
nf := 4	Number of flange bolts each side of cross tube
tf = 0.170 · in	Fwd minimum saddle material thickness
ta := 0.225 · in	Aft minimum saddle material thickness
trf := txf - tf	Fwd rib thickness
tra := txa - ta	Aft rib thickness
$\mu := 0.8$	Conservative aluminum on aluminum friction co-efficient (see table on Page 12 of Reference 2)
trf = 0.1 · in	
tra = 0.09 · in	

WAS 0.175



Revision: A
Date: 99.10.15

7.0 Saddle Comparisons

A comparison between the fatigue curves for unnotched 2014-T6 material vs. unnotched 6061-T6 material shows that the 6061-T6 material used in Dart saddles is better than the 2014-T6 material used in Bell saddles (see Ref 2 Pages 9 and 10b). A reduction factor of $0.65/0.74=0.88$ will therefore be applied in comparing Bell saddle material allowables to Dart saddle material allowables.

$$ff := 0.88$$

Fatigue factor

7.1 Lower Saddle Strength Comparison

The lower section of the Dart saddle is the same for both the D2917/D2918 forward saddle and the D2919/D2920 aft saddle.

$$Ads := 2 \cdot tg \cdot (Ld - 4 \cdot Df)$$

$$Ads = 3.91 \cdot \text{in}^2$$

Area of Dart saddle in tension/compression

$$Abf := 2 \cdot tmatf \cdot (Lb - 4 \cdot d4 - 2 \cdot d5)$$

$$Abf = 1.59 \cdot \text{in}^2$$

Area of fwd Bell saddle in tension/compression

$$Aba := 2 \cdot tmata \cdot (Lb - 4 \cdot d4 - 2 \cdot d5)$$

$$Aba = 1.98 \cdot \text{in}^2$$

Area of aft Bell saddle in tension/compression

Ultimate Tensile Strength

$$Ftud := Ftu3 \cdot Ads$$

$$Ftud = 164272 \cdot \text{lb}$$

Dart allowable ultimate tensile force

$$Ftubf := Ftu4 \cdot Abf \cdot ff$$

$$Ftubf = 91177 \cdot \text{lb}$$

Fwd Bell allowable tensile force (ultimate)

$$Ftuba := Ftu4 \cdot Aba \cdot ff$$

$$Ftuba = 113059 \cdot \text{lb}$$

Aft Bell allowable tensile force (ultimate)

$$MS1f := \frac{Ftud}{Ftubf} - 1$$

$$MS1f = 0.80$$

Margin of Safety - Dart fwd saddle
(lower section) in tension (ultimate)

$$MS1a := \frac{Ftud}{Ftuba} - 1$$

$$MS1a = 0.45$$

Margin of Safety - Dart aft saddle
(lower section) in tension (ultimate)

Compressive Yield Strength

$$Fcyd := Fcy3 \cdot Ads$$

$$Fcyd = 136894 \cdot \text{lb}$$

Dart allowable compressive force (yield)

$$Fcybf := Fcy4 \cdot Abf \cdot ff$$

$$Fcybf = 82760 \cdot \text{lb}$$

Fwd Bell allowable compressive force (yield)

$$Fcyba := Fcy4 \cdot Aba \cdot ff$$

$$Fcyba = 102623 \cdot \text{lb}$$

Aft Bell allowable compressive force (yield)

$$MS2f := \frac{Fcyd}{Fcybf} - 1$$

$$MS2f = 0.65$$

Margin of Safety - Dart fwd saddle
(lower section) in compression (yield)

$$MS2a := \frac{Fcyd}{Fcyba} - 1$$

$$MS2a = 0.33$$

Margin of Safety - Dart aft saddle
(lower section) in compression (yield)

Tensile Yield Strength

$$Ftyd := Fty3 \cdot Ads$$

$$Ftyd = 136894 \cdot \text{lb}$$

Dart allowable tensile force (yield)

$$Ftybf := Fty4 \cdot Abf \cdot ff$$

$$Ftybf = 78552.32 \cdot \text{lb}$$

Fwd Bell allowable tensile force (yield)

$$Ftyba := Fty4 \cdot Aba \cdot ff$$

$$Ftyba = 97405 \cdot \text{lb}$$

Aft Bell allowable tensile force (yield)

$$MS3f := \frac{Ftyd}{Ftybf} - 1$$

$$MS3f = 0.74$$

Margin of Safety - Dart fwd saddle
(lower section) in tension (yield)

$$MS3a := \frac{Ftyd}{Ftyba} - 1$$

$$MS3a = 0.41$$

Margin of Safety - Dart aft saddle
(lower section) in tension (yield)

Shear Strength

$F_{sd} := A_{ds} \cdot F_{su3}$	$F_{sd} = 105604 \cdot \text{lb}$	Dart allowable shear force (ultimate)
$F_{sbf} := A_{bf} \cdot F_{su4 \cdot ff}$	$F_{sbf} = 56109 \cdot \text{lb}$	Fwd Bell allowable shear force (ultimate)
$F_{sba} := A_{ba} \cdot F_{su4 \cdot ff}$	$F_{sba} = 69575 \cdot \text{lb}$	Aft Bell allowable shear force (ultimate)
$MS_{4f} := \frac{F_{sd}}{F_{sbf}} - 1$	$MS_{4f} = 0.88$	Margin of Safety - Dart fwd saddle (lower section) in shear (ultimate)
$MS_{4a} := \frac{F_{sd}}{F_{sba}} - 1$	$MS_{4a} = 0.52$	Margin of Safety - Dart aft saddle (lower section) in shear (ultimate)

7.2 Saddle to Skidtube Fastener Comparison

In order to compare the fasteners holding the saddles onto the skidtube, the fastener shear strengths, the shear tear-out of the saddle material, and saddle material bearing allowables must be considered. The margin of safety comparison will then be completed by comparing the weakest link of each configuration.

Fastener Shear Strengths

Dart saddles are held onto the skidtube with 4 AN4 bolts and D2570 stainless steel bushings. Additionally, the Dart system has a redundant load path for attaching the saddle to the skidtube. The saddle is configured to interlock over a flange on the extruded Dart skidtube.

The strength of the bolt and bushing combination is calculated as follows:

$D_b := 0.257 \cdot \text{in}$		D2570 stainless steel bushing hole size
$F_{subush} := 50000 \cdot \text{lb} \cdot \text{in}^{-2}$		Bushing material shear strength (Ref. 2 Pg. 13)
$A_{bush} := \frac{\pi}{4} \cdot (D_f^2 - D_b^2)$	$A_{bush} = 0.1 \cdot \text{in}^2$	Bushing area
$F_{bush} := F_{subush} \cdot A_{bush}$	$F_{bush} = 4939.96 \cdot \text{lb}$	Bushing allowable shear force
$F_{fast} := F_{bush} + F_{suAN4}$	$F_{fast} = 8619.96 \cdot \text{lb}$	Total shear force through bolt and bushing

Shear failure of the fasteners holding the Dart saddles onto the skidtube occurs when the bolts and bushings as well as the ridge on the outside of the skidtube fails.

$A_s := w_f \cdot L_d - \pi \cdot D_f^2$	$A_s = 5.4 \cdot \text{in}^2$	
$F_{flange} := 2 \cdot F_{su1} \cdot A_s$	$F_{flange} = 280660 \cdot \text{lb}$	
$F_{tot} := F_{fast \cdot nt} + F_{flange}$	$F_{tot} = 349619 \cdot \text{lb}$	Dart allowable shear force

Shear failure of the fasteners holding the Bell saddles and skidtube occurs when the rivets holding the saddles onto the skidtube fail.

$F_{riv} := n_4 \cdot F_{suAN4} + n_5 \cdot F_{suAN5}$	$F_{riv} = 68080 \cdot \text{lb}$	Bell allowable shear force
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Shear Tear-out of the Saddle Material

Shear tearout of the Dart configuration occurs when the bolts and bushings tear through the ridge and when the ridge tears off the saddle.

$F_{dtear} := F_{su3} \cdot (2 \cdot n_t \cdot e_f \cdot t_g + 2 \cdot L_d \cdot t_{over})$	$F_{dtear} = 160062 \cdot \text{lb}$	Dart tear-out force
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Shear tearout of the Bell configuration occurs when the MS27039-4/MS27039-5 bolts tear through the saddle material.

$$\begin{aligned} \text{Fbt ear1} &:= \text{Fsu4} \cdot \text{ff} \cdot \text{tmatf} \cdot (2 \cdot \text{n4} \cdot \text{e4} + 2 \cdot \text{n5} \cdot \text{e5}) & \text{Fbt ear1} &= 26435 \cdot \text{lb} & \text{Bell tear-out force of fwd saddle} \\ \text{Fbt ear2} &:= \text{Fsu4} \cdot \text{ff} \cdot \text{tmata} \cdot (2 \cdot \text{n4} \cdot \text{e4} + 2 \cdot \text{n5} \cdot \text{e5}) & \text{Fbt ear2} &= 32780 \cdot \text{lb} & \text{Bell tear-out force of aft saddle} \end{aligned}$$

Bearing of the Fasteners on the Saddle Material

$$\text{Abf} = 2 \cdot \text{tflange} \cdot \text{Ld} \qquad \text{Abf} = 0.80 \cdot \text{in}^2 \qquad \text{Bearing area of Dart saddles}$$

Ultimate Bearing Allowable

$$\begin{aligned} \text{Bud} &:= \text{nt} \cdot \text{Df} \cdot \text{tg} \cdot \text{Fbru3} + \text{Fbru1} \cdot \text{Abf} & \text{Bud} &= 162114 \cdot \text{lb} & \text{Dart allowable bearing force (ultimate)} \\ \text{Bub1} &:= (\text{n4} \cdot \text{d4} + \text{n5} \cdot \text{d5}) \cdot \text{Fbru4} \cdot \text{tmatf} \cdot \text{ff} & \text{Bub1} &= 54066 \cdot \text{lb} & \text{Bell allowable bearing force (fwd, ultimate)} \\ \text{Bub2} &:= (\text{n4} \cdot \text{d4} + \text{n5} \cdot \text{d5}) \cdot \text{Fbru4} \cdot \text{tmata} \cdot \text{ff} & \text{Bub2} &= 67042 \cdot \text{lb} & \text{Bell allowable bearing force (aft, ultimate)} \end{aligned}$$

Yield Bearing Allowable

$$\begin{aligned} \text{Byd} &:= \text{nt} \cdot \text{Df} \cdot \text{tg} \cdot \text{Fbry3} + \text{Fbry1} \cdot \text{Abf} & \text{Byd} &= 111612 \cdot \text{lb} & \text{Dart allowable bearing force (yield)} \\ \text{Byb1} &:= (\text{n4} \cdot \text{d4} + \text{n5} \cdot \text{d5}) \cdot \text{Fbry4} \cdot \text{tmatf} \cdot \text{ff} & \text{Byb1} &= 39560 \cdot \text{lb} & \text{Bell allowable bearing force (fwd, yield)} \\ \text{Byb2} &:= (\text{n4} \cdot \text{d4} + \text{n5} \cdot \text{d5}) \cdot \text{Fbry4} \cdot \text{tmata} \cdot \text{ff} & \text{Byb2} &= 49055 \cdot \text{lb} & \text{Bell allowable bearing force (aft, yield)} \end{aligned}$$

Margin of Safety

The above analysis shows that the Bell saddles will fail in shear tear-out before the fasteners fail or the saddles fail in bearing. The Dart saddles will fail in bearing before they fail in shear tear-out or before the fasteners fail.

$$\begin{aligned} \text{MS5f} &:= \frac{\text{Byd}}{\text{Fbt ear1}} - 1 & \text{MS5f} &= 3.22 & \text{Margin of Safety - Dart fwd saddle-to-skidtube fastener failure} \\ \text{MS5a} &:= \frac{\text{Byd}}{\text{Fbt ear2}} - 1 & \text{MS5a} &= 2.40 & \text{Margin of Safety - Dart aft saddle-to-skidtube fastener failure} \end{aligned}$$

7.3 Saddle to Crosstube Fastener Strength Comparison

In order to compare the fasteners holding the saddles onto the crosstubes, the fastener shear strengths and saddle material bearing allowables must be considered. The margin of safety comparison will then be completed by comparing the weakest link of each configuration.

A significant advantage of the Dart saddle clamping system is that the friction between the saddle and the crosstube reduces the load transferred to the bolts to resist twisting moments. The installation instructions include torquing instructions to ensure that this friction load carrying capability is developed. The method used to calculate this friction force is outlined in Figure 4 of Reference 1.

$$\begin{aligned} \text{Fa} &:= 3130 \cdot \text{lb} & \text{Axial force per flange bolt} \\ \text{Fmax} &:= 0.9 \cdot \text{nf} \cdot \text{Fa} & \text{Fmax} &= 11268 \cdot \text{lb} & \text{Total force exerted by all flange bolts} \\ \text{N} &:= 2 \cdot \pi \cdot \text{Fmax} & \text{N} &= 70798.93 \cdot \text{lb} & \text{Normal force on crosstube} \\ \text{Ff} &:= \mu \cdot \text{N} & \text{Ff} &= 56639.15 \cdot \text{lb} & \text{Friction force between saddle and crosstube} \end{aligned}$$

Fastener Shear Strength

Dart saddles are held onto the crosstubes with 2 AN5 through-bolts and the friction force that is created by bolting the 2 halves of the saddles together.

$$\text{Fsd} := \text{Ff} + \text{ncd} \cdot \text{FsuAN5} \qquad \text{Fsd} = 79639 \cdot \text{lb} \qquad \text{Twisting force allowed before Dart saddle to crosstube bolts fail in shear}$$

Bell saddles are held onto the crosstubes with 12 MS90354-1006 rivets but there is no friction force to resist twisting moments between the skidtube and the crosstube.

$$F_{sb} := ncb \cdot F_{su1006}$$

$$F_{sb} = 102000 \cdot lb$$

Twisting force allowed before Bell saddle to crosstube rivets fail in shear

Bearing of the Fasteners on the Saddle Material

Ultimate Bearing Allowable

$$B_{ud} := F_f + ncd \cdot dcd \cdot txf \cdot F_{bru3}$$

$$B_{ud} = 85836 \cdot lb$$

Twisting force allowed before Dart saddles fail in bearing (ultimate)

$$B_{ub1} := ncb \cdot dcb \cdot tmatf \cdot F_{bru4} \cdot ff$$

$$B_{ub1} = 50819 \cdot lb$$

Twisting force allowed before Bell fwd saddles fail in bearing (ultimate)

$$B_{ub2} := ncb \cdot dcb \cdot tmatf \cdot F_{bru4} \cdot ff$$

$$B_{ub2} = 63015 \cdot lb$$

Twisting force allowed before Bell aft saddles fail in bearing (ultimate)

Yield Bearing Allowable

$$B_{yd} := F_f + ncd \cdot dcd \cdot txf \cdot F_{bry3}$$

$$B_{yd} = 75882 \cdot lb$$

Twisting force allowed before Dart saddles yield in bearing (yield)

$$B_{yb1} := ncb \cdot dcb \cdot tmatf \cdot F_{bry4} \cdot ff$$

$$B_{yb1} = 37184 \cdot lb$$

Twisting force allowed before Bell fwd saddles yield in bearing (yield)

$$B_{yb2} := ncb \cdot dcb \cdot tmatf \cdot F_{bry4} \cdot ff$$

$$B_{yb2} = 46109 \cdot lb$$

Twisting force allowed before Bell aft saddles yield in bearing (yield)

Margin of Safety

The above analysis shows that the Bell saddles will fail in bearing before the fasteners that hold the saddles onto the crosstubes fail. In the Dart configuration, the fasteners will fail in shear before the saddles will fail in bearing.

$$MS_{6f} := \frac{F_{sd}}{B_{yb1}} - 1$$

$$MS_{6f} = 1.14$$

Margin of Safety - Dart fwd saddle-to-crosstube fastener failure

$$MS_{6a} := \frac{F_{sd}}{B_{yb2}} - 1$$

$$MS_{6a} = 0.73$$

Margin of Safety - Dart aft saddle-to-crosstube fastener failure

7.4 Upper Saddle Strength Comparison

This calculation checks the strength of the saddle material through the critical cross section illustrated in Figure 5 of Reference 1. The estimates for the inertia values and the area of this cross section are also shown in the Reference section.

$$L_f := \frac{L_d}{2} - ctubefwd$$

$$L_f = 2.61 \cdot in$$

Dart forward saddle flange length

$$L_a := \frac{L_d}{2} - ctubeaft$$

$$L_a = 2.50 \cdot in$$

Dart aft saddle flange length

$$CG_{xf} := ctubefwd + 0.5 \cdot L_f$$

$$CG_{xf} = 2.69 \cdot in$$

Dart forward Center of Gravity of flange

$$CG_{yf} := ctubefwd + tf + \frac{trf}{2}$$

$$CG_{yf} = 1.61 \cdot in$$

Dart forward Center of Gravity of rib

$$CG_{xa} := ctubeaft + 0.5 \cdot L_a$$

$$CG_{xa} = 2.75 \cdot in$$

Dart aft Center of Gravity of flange

$$CG_{ya} := ctubeaft + tf + \frac{tra}{2}$$

$$CG_{ya} = 1.72 \cdot in$$

Dart aft Center of Gravity of rib

$$\begin{aligned}
 Isxf &:= \frac{\pi}{4} \left[(ctubefwd + tf)^4 - ctubefwd^4 \right] + 4 \cdot \left(\frac{1}{12} \cdot tf \cdot Lf^3 + tf \cdot Lf \cdot CGxf^2 \right) & Isxf &= 15.61 \cdot \text{in}^4 \\
 Isyf &:= \frac{\pi}{4} \left[(ctubefwd + tf)^4 - ctubefwd^4 \right] + 2 \cdot \left[\frac{1}{12} \cdot 1.5 \cdot tw \cdot trf^3 + 1.5 \cdot tw \cdot trf \cdot CGyf^2 + Lf \cdot tf \cdot \left(\frac{g}{2} + \frac{tf}{2} \right)^2 \right] & Isyf &= 2.28 \cdot \text{in}^4 \\
 Asf &:= \pi \left[(ctubefwd + tf)^2 - ctubefwd^2 \right] + 4 \cdot tf \cdot Lf + 2 \cdot 1.5 \cdot tw \cdot trf & Asf &= 3.56 \cdot \text{in}^2 \\
 Isxa &:= \frac{\pi}{4} \left[(ctubeaft + ta)^4 - ctubeaft^4 \right] + 4 \cdot \left(\frac{1}{12} \cdot ta \cdot La^3 + ta \cdot La \cdot CGxa^2 \right) & Isxa &= 21.17 \cdot \text{in}^4 \\
 Isya &:= \frac{\pi}{4} \left[(ctubeaft + ta)^4 - ctubeaft^4 \right] + 2 \cdot \left[\frac{1}{12} \cdot 1.5 \cdot tw \cdot tra^3 + 1.5 \cdot tw \cdot tra \cdot CGya^2 + Lf \cdot ta \cdot \left(\frac{g}{2} + \frac{ta}{2} \right)^2 \right] & Isya &= 3.59 \cdot \text{in}^4 \\
 Asa &:= \pi \left[(ctubeaft + ta)^2 - ctubeaft^2 \right] + 4 \cdot ta \cdot La + 2 \cdot 1.5 \cdot tw \cdot tra & Asa &= 5.75 \cdot \text{in}^2
 \end{aligned}$$

The inertias of the Bell saddles are based on the circular cross section shown in Figure 3 of Reference 1.

$$\begin{aligned}
 Ibf &:= \frac{1}{4} \cdot \pi \left[(ctubefwd + tmatf)^4 - ctubefwd^4 \right] & Ibf &= 1.2 \cdot \text{in}^4 & \text{Bell forward saddle inertia} \\
 Abf &:= \pi \left[(ctubefwd + tmatf)^2 - ctubefwd^2 \right] & Abf &= 1.14 \cdot \text{in}^2 & \text{Bell forward saddle area} \\
 Iba &:= \frac{1}{4} \cdot \pi \left[(ctubeaft + tmata)^4 - ctubeaft^4 \right] & Iba &= 1.92 \cdot \text{in}^4 & \text{Bell aft saddle inertia} \\
 Aba &:= \pi \left[(ctubeaft + tmata)^2 - ctubeaft^2 \right] & Aba &= 1.54 \cdot \text{in}^2 & \text{Bell aft saddle area}
 \end{aligned}$$

Ultimate Bending Allowable

$$\begin{aligned}
 Mduf1 &:= \frac{Ftu3 \cdot Isxf \cdot 2}{Ld} & Mduf1 &= 163938 \cdot \text{lb} \cdot \text{in} & \text{Dart fwd-aft bending allowable for forward saddle} \\
 Mduf2 &:= \frac{Ftu3 \cdot Isyf}{ctubefwd + txf} & Mduf2 &= 58008 \cdot \text{lb} \cdot \text{in} & \text{Dart inboard-outboard bending allowable for fwd saddle} \\
 Mdua1 &:= \frac{Ftu3 \cdot Isxa \cdot 2}{Ld} & Mdua1 &= 222239 \cdot \text{lb} \cdot \text{in} & \text{Dart fwd-aft bending allowable for forward saddle} \\
 Mdua2 &:= \frac{Ftu3 \cdot Isya}{ctubeaft + txa} & Mdua2 &= 83148 \cdot \text{lb} \cdot \text{in} & \text{Dart inboard-outboard bending allowable for aft saddle} \\
 Mbuf &:= \frac{Ftu4 \cdot Ibf \cdot ff}{ctubefwd + tmatf} & Mbuf &= 45392 \cdot \text{lb} \cdot \text{in} & \text{Bell bending allowable for forward saddle} \\
 Mbua &:= \frac{Ftu4 \cdot Iba \cdot ff}{ctubeaft + tmata} & Mbua &= 66227 \cdot \text{lb} \cdot \text{in} & \text{Bell bending allowable for aft saddle}
 \end{aligned}$$

$$MS7f := \frac{Mduf1}{Mbuf} - 1$$

$$MS7a := \frac{Mdua1}{Mbua} - 1$$

$$MS8f := \frac{Mduf2}{Mbuf} - 1$$

$$MS8a := \frac{Mdua2}{Mbua} - 1$$

$$MS7f = 2.61$$

$$MS7a = 2.36$$

$$MS8f = 0.28$$

$$MS8a = 0.26$$

Margin of Safety - Dart fwd-aft bending allowable for forward saddle (ultimate)

Margin of Safety - Dart fwd-aft bending allowable for aft saddle (ultimate)

Margin of Safety - Dart inboard-outboard bending allowable for forward saddle (ultimate)

Margin of Safety - Dart inboard-outboard bending allowable for aft saddle (ultimate)

STILL POSITIVE

Compressive Yield Bending Allowable

$M_{dycf1} := \frac{F_{cy3} \cdot I_{sxf} \cdot 2}{L_d}$	$M_{dycf1} = 136615 \cdot \text{lb} \cdot \text{in}$	Dart fwd-aft bending allowable for forward saddle
$M_{dycf2} := \frac{F_{cy3} \cdot I_{syf}}{ctubefwd + t_{xf}}$	$M_{dycf2} = 48340 \cdot \text{lb} \cdot \text{in}$	Dart inboard-outboard bending allowable for fwd saddle
$M_{dyca1} := \frac{F_{cy3} \cdot I_{sxa} \cdot 2}{L_d}$	$M_{dyca1} = 185199 \cdot \text{lb} \cdot \text{in}$	Dart fwd-aft bending allowable for forward saddle
$M_{dyca2} := \frac{F_{cy3} \cdot I_{sya}}{ctubeaft + t_{xa}}$	$M_{dyca2} = 69290 \cdot \text{lb} \cdot \text{in}$	Dart inboard-outboard bending allowable for aft saddle
$M_{byf} := \frac{F_{cy4} \cdot I_{bf} \cdot ff}{ctubefwd + t_{matf}}$	$M_{byf} = 41202 \cdot \text{lb} \cdot \text{in}$	Bell bending allowable for forward saddle
$M_{bya} := \frac{F_{cy4} \cdot I_{ba} \cdot ff}{ctubeaft + t_{mata}}$	$M_{bya} = 60114 \cdot \text{lb} \cdot \text{in}$	Bell bending allowable for aft saddle
$MS9f := \frac{M_{dycf1}}{M_{byf}} - 1$	$MS9f = 2.32$	Margin of Safety - Dart fwd-aft bending allowable for forward saddle (compressive yield)
$MS9a := \frac{M_{dyca1}}{M_{bya}} - 1$	$MS9a = 2.08$	Margin of Safety - Dart fwd-aft bending allowable for aft saddle (compressive yield)
$MS10f := \frac{M_{dycf2}}{M_{byf}} - 1$	$MS10f = 0.17$	Margin of Safety - Dart inboard-outboard bending allowable for forward saddle (compressive yield)
$MS10a := \frac{M_{dyca2}}{M_{bya}} - 1$	$MS10a = 0.15$	Margin of Safety - Dart inboard-outboard bending allowable for aft saddle (compressive yield)

STILL POSITIVE

Tensile Yield Bending Allowable

$M_{dytf1} := \frac{F_{ty3} \cdot I_{sxf} \cdot 2}{L_d}$	$M_{dytf1} = 136615 \cdot \text{lb} \cdot \text{in}$	Dart fwd-aft bending allowable for forward saddle
$M_{dytf2} := \frac{F_{ty3} \cdot I_{syf}}{ctubefwd + t_{xf}}$	$M_{dytf2} = 48340 \cdot \text{lb} \cdot \text{in}$	Dart inboard-outboard bending allowable for fwd saddle
$M_{dyta1} := \frac{F_{ty3} \cdot I_{sxa} \cdot 2}{L_d}$	$M_{dyta1} = 185199 \cdot \text{lb} \cdot \text{in}$	Dart fwd-aft bending allowable for forward saddle
$M_{dyta2} := \frac{F_{ty3} \cdot I_{sya}}{ctubeaft + t_{xa}}$	$M_{dyta2} = 69290 \cdot \text{lb} \cdot \text{in}$	Dart inboard-outboard bending allowable for aft saddle

$$M_{byf} := \frac{F_{ty4} \cdot I_{bf} \cdot ff}{ctube_{fwd} + t_{matf}}$$

$$M_{byf} = 39107 \cdot \text{lb} \cdot \text{in}$$

Bell bending allowable for forward saddle

$$M_{bya} := \frac{F_{ty4} \cdot I_{ba} \cdot ff}{ctube_{aft} + t_{mata}}$$

$$M_{bya} = 57057 \cdot \text{lb} \cdot \text{in}$$

Bell bending allowable for aft saddle

$$MS_{11f} := \frac{M_{dytf1}}{M_{byf}} - 1$$

$$MS_{11f} = 2.49$$

Margin of Safety - Dart fwd-aft bending allowable for forward saddle (tensile yield)

$$MS_{11a} := \frac{M_{dyta1}}{M_{bya}} - 1$$

$$MS_{11a} = 2.25$$

Margin of Safety - Dart fwd-aft bending allowable for aft saddle (tensile yield)

$$MS_{12f} := \frac{M_{dytf2}}{M_{byf}} - 1$$

$$MS_{12f} = 0.24$$

Margin of Safety - Dart inboard-outboard bending allowable for forward saddle (tensile yield)

$$MS_{12a} := \frac{M_{dyta2}}{M_{bya}} - 1$$

$$MS_{12a} = 0.21$$

Margin of Safety - Dart inboard-outboard bending allowable for aft saddle (tensile yield)

Shear Allowable

$$F_{sudf} := F_{su3} \cdot A_{sf}$$

$$F_{sudf} = 96209 \cdot \text{lb}$$

Dart shear force allowable

$$F_{suda} := F_{su3} \cdot A_{sa}$$

$$F_{suda} = 155204 \cdot \text{lb}$$

Dart shear force allowable

$$F_{subf} := F_{su4} \cdot A_{bf} \cdot ff$$

$$F_{subf} = 40101 \cdot \text{lb}$$

Bell shear force allowable for forward saddle

$$F_{suba} := F_{su4} \cdot A_{ba} \cdot ff$$

$$F_{suba} = 54078 \cdot \text{lb}$$

Bell shear force allowable for aft saddle

$$MS_{13f} := \frac{F_{sudf}}{F_{subf}} - 1$$

$$MS_{13f} = 1.4$$

Margin of Safety - Dart shear allowable for fwd saddle

$$MS_{13a} := \frac{F_{suda}}{F_{suba}} - 1$$

$$MS_{13a} = 1.87$$

Margin of Safety - Dart shear allowable for aft saddle

8.0 Skidtube Comparisons8.1 General Information

It is an important aspect of skidtube design that the structure maintain its shape to preserve inertial properties. Experience has shown that round tubes lose at least 10% of their primary inertial properties under bending conditions.

$$f_b := 0.90$$

Secondly, the analysis of section 7.4 shows that Dart saddles are significantly stiffer than Bell saddles in the principal skidtube bending direction therefore increasing the rigidity of the supports in a beam analysis. In terms of bending moments resulting from a centrally located load P over a beam of length L, a pinned-pinned beam must be designed for bending moments of the magnitude PL/4 while a fixed-fixed beam must be designed for bending moments of the magnitude PL/8. The allowable bending moments in a pinned-pinned beam are therefore half of the allowable bending moments in fixed-fixed beam. Because of the difference in end conditions between a Dart skidtube and a Bell skidtube, a reduction factor will be applied to the allowable bending moments in Bell skidtubes.

$$f_e := 0.90$$

STILL POSITIVE
6 SADDLES
SUFFICIENTLY STRONG
WITH 0.175 WALL
CP 9.10.07